Using Agile Practices in Global Software Development: A Systematic Review

Emam Hossain[1] Muhammad Ali Babar [2] Hye-young Paik [1]

[1] University of New South Wales, Australia
{meh,hpaik}@cse.unsw.edu.au
[2] Lero, Ireland
Muhammad.AliBabar@lero.ie

Technical Report
UNSW-CSE-TR-0904
March 2009

School of Computer Science and Engineering
The University of New South Wales
Sydney 2052, Australia

Abstract

There is a growing interest in applying agile approaches in Global Software Development (GSD) projects. Recently, some studies have reported the use of Scrum practices in distributed development projects. However, little is known about how these practices are carried out in reality and what the outcomes are. We have conducted a systematic literature review to identify, synthesize and present the findings from the primary studies that report using Scrum practices in GSD projects. Our search strategy identified 583 papers, of which 20 were identified as primary papers relevant to our research. We extracted data from these papers to identify various challenges of using Scrum in GSD. Current strategies to deal with the identified challenges have also been extracted. This paper presents the review's findings that are expected to help researchers and practitioners to understand the current state of use of Scrum practices in GSD.

1 Introduction

The trend in the recent software development industry is to move towards Global Software Development (GSD). This is driven by a number of factors such as improved network infrastructure, access to large move towards component-based architecture and increased time-to-market pressure [5, 6]. Despite its popularity, the question of "which agile practices are effective for GSD under which circumstances?" has not been closely researched yet [9]. Agile Software Development (ASD) paradigm has gained significant attention due to its flexible approach to managing the requirement volatility and emphasis on extensive collaboration between customers and developers [1]. Recently, we have observed that an increased number of GSD project managers are seriously considering introducing agile practices. Because the idea of applying agile practices in the context of GSD is still in its early days, there has not been much research work done in this area. Given the increased interest in applying agile practices in GSD projects, it appears worthwhile for the practitioners and researchers to investigate the relevant experiences reported in the literature to learn how effective agile approaches are in GSD. Such investigation will also reveal when a particular approach or practice is considered suitable.

Due to the fact that agile practices are based on the philosophy of close, frequent and collocated collaborations, the geographical distance in GSD alone can present a challenge. Through a number of reports by GSD practitioners in the literature, we have found that, despite the obvious difficulties, there are some instances of success of using agile practices with distributed teams [S1-S5]. But other researchers [8] still argue that the fundamental question on whether agile practices can be used in a distributed setting is still open to debate. As mentioned before, the study into applying agile project management practice in the context of GSD still has many questions. Although there is some published research, little is known about how the practices are carried out in reality and what the outcomes are. To address this research challenge, this systematic literature review seeks to evaluate, synthesize, and present the studies on using agile project management practices in GSD to date. The next section gives an overview of Scrum method and discusses the motivation of this research. Section 3 describes the research methods used. The results of this study are presented in Section 4. Section 5 discusses the findings to draw some conclusions. The limitations of the study are mentioned in Section 6. Section 7 closes the paper with a brief discussion of the researchable issues on this topic.

2 Background and Motivation

eXtreme Programming (XP) and Scrum are the most well known Agile Software Development methodologies [1]. XP focuses primarily on the implementation of software, while Scrum focuses on project management. In this review, we only investigate agile practices that pertain to software project management. We chose Scrum as it is the most widely adopted agile project management method. In this section, we first introduce the Scrum method, place the studied practice in the context of GSD and more concretely justify the need for this review.

2.1 Scrum

Scrum is an iterative and incremental project management approach that provides a simple "inspect and adapt" framework. In Scrum, software is delivered in increments called "Sprints" (usually 2-4 weeks iterations) [10]. Each sprint starts with planning and ends with a review. A sprint planning by a Scrum team is a time-boxed meeting, which could last up to 4 hours. It is dedicated to developing detailed plans for the sprint. The Stakeholders of a project attend sprint review meetings to review the state of the business, the market and technology. These meetings could also last up to 4 hours. A retrospective meeting may be scheduled to assess the teamwork in the completed sprints. A daily Scrum meeting by a Scrum team is a 15-minute long and each team member addresses three questions: what did I do yesterday, what will I do today and what impediments are in my way? Scrum produces three artefacts, namely: product backlogs, sprint backlogs and burn-down charts. Backlogs contain customer requirements and daily burn down charts show the cumulative work remaining.

2.2 Scrum in Global Software Development

Agile approaches are usually considered effective for the projects with high uncertainty [1]. Paasivaara et al [S1] reported that distributed software development projects with volatile requirements and uncertain implementation technologies used various agile and agility supporting practices for effectively organizing and managing distributed development projects. Scrum has been already found as effective approach to managing projects with many small, collocated development teams [2]. Sutherland and Schwaber [10] argue that Scrum can also be used for large and distributed teams. Indeed, from the papers reviewed in this review, we have found projects in which Scrum has been successfully used.

2.3 Objectives of this Review

It is apparently difficult to apply many of the key concepts of agile practices in GSD because of the physical separation of the members of a development team [2].Different project contextual factors (e.g., size, budget, complexity) may also limit the use of tools and technology, or agility supporting practices such as visits and cultural liaison [9]. In a recent survey about agile practice adoption rate [3], 69% of the respondents indicated that their organizations are using agile practices. The success rates of using agile methodology has been reported 82% for collocated teams, 72% for near located (next building, working from home, etc) and 60% for significantly distributed teams. Another survey concludes that among the various agile practices, project management methods such as Scrum have a higher adoption rate [4]. Thus, we can argue that Scrum, as an agile practice, is becoming increasingly popular and also applicable in GSD projects. For this reason we have decided to investigate how Scrum is being used in GSD projects.

3 Research Method

This research has been carried out by following Kitchenham's guidelines for conducting systematic reviews [10], which involve several activities such as the development of review protocol, the identification and selection of primary studies, the data extraction and synthesis, and reporting the results. We followed all these steps for the reported study as described in the following Sections of this paper. The broad objective of this study is to answer the following research question. RQ. What is currently known about the use of the Scrum practices in GSD projects? More specifically, this study focuses on the following two questions:

- RQ1. What are the challenges of using the Scrum practices in GSD projects?
- RQ2. What are the strategies being used to deal with the challenges of using the Scrum practices in GSD projects?

3.1 Data Sources and Search Strategies

We only searched for papers that are written in English and available online. The search strategy included electronic databases and manual searches of conference proceedings. The following electronic databases were used.

- IEEEXplore (www.ieeexplore.ieee.org/Xplore/)
- ACM Digital library (www.portal.acm.org/dl.cfm)
- Google Scholar (http://scholar.google.com.au/)
- Compendex EI (www.engineeringvillage2.org/)
- Wiley InterSciene (www.interscience.wiley.com/)
- Elsevier Science Direct (www.sceincedirect.com/)
- AIS eLibrary (www.aisel.aisnet.org/)
- SpringerLink (www.springerlink.com/)

In addition, we searched the following conference proceedings for papers that discuss the use of the Scrum practice(s) in GSD context.

- Agile Processes in Software Engineering and Extreme Programming (XP/Agile Universe)
- Agile Conference

The types of papers ranged from industry experience reports, theoretical, empirical and experimental academic papers. Figure 3.1 shows the systematic review process and the number of papers identified at each stage. In stage 1, we searched the databases using the search terms listed in Table 3.1. Category 1 has more keywords and shows many variations of the same term "Global Software Development". All these search items were combined by using the Boolean "`AND`" operator, which entails that an article that focus on both Agile

and Global Software Development will be retrieved. That is, we searched every items of: Category Type 1 `AND` Category Type 2.

The search excluded articles that address editorials, prefaces, article, reviews, discussion comments, news, summaries of tutorials, workshops, panels and poster sessions. This search strategy resulted in a total of 583 "hits" that included 366 unduplicated papers.

Table 3.1: Search terms used in this review

Type	Category	Keywords
1	Global Software Development	Collaborative software development, Cross continent development, Distributed software development, Dispersed teams, Distributed development, Geographically distributed software development, Global software development, Global software engineering, Offshore, Off shoring
2	Use of agile practices	Agile, Agile practice, Agile methods, Scrum, Scrum practice, Scrum method

3.2 Managing Studies and inclusion Decisions

Our study followed the citation management procedure reported by Dyba and Dingsoyr [7]. We used EndNote for storing relevant citations from stage 1 (n=366). The citations were then imported to an Excel sheet where we recorded the sources of each citation and subsequent inclusion / exclusion decision. We maintained separate Endnote library and Excel sheets for each stage. In the second and third stages, we carefully went through the titles and abstracts of all the retrieved citations to determine their relevance. In case of conflict, we sought advice from a domain expert for verification. At the end of stage 3, we were left with 77 papers for stage 4 of the selection process.

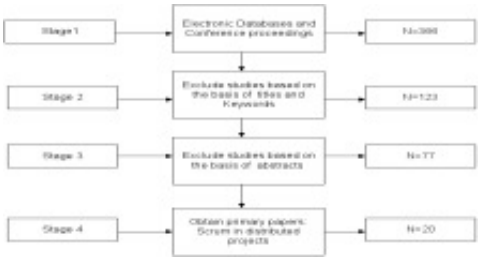

Figure 3.1: The selection process of primary papers

3.3 Final Selection

We used the following screening criteria to ensure the papers address our research topic.

1. Does a paper focus on the discussion of agile practices in distributed settings?
2. Does a paper address the use of any Scrum practices in distributed projects?
3. Does a paper discuss any real life experience of using Scrum practices in distributed projects?

These 3 points provided a measure of the extent to which we are confident that a selected paper could make a valuable contribution to understanding the current use of Scrum practices in distributed setting. We selected 21 papers out of the 77 articles by carrying out the quality assessment based on three screening criteria. For example, we excluded a number of papers that discussed some other agile methods and practices (e.g. XP, pair programming). Among the 21 papers, we found that one journal paper [S1] was an extended version of previously published conference paper [S1a]. We also found that two papers [S3] and [S3a] published in two different conferences were based on the same empirical study. In Both cases, we included the comprehensive recently published papers as mentioned in appendix A. We included another journal paper [S8] that was not retrieved through our search of electronic databases but was cited by some of the papers [S1, S4] included in our review and this paper [S8] appeared to be within the scope of the research. Finally we selected 20 papers (excluding two repeated papers S1a and S3a and including one journal paper S8 from extracted 21 papers) for data extraction and synthesis phases. We have enlisted the selected primary studies in the appendix A.

3.4 Data Extraction and Synthesis

From the final selection, we extracted data using a pre-defined extraction form shown in Appendix B. During data extraction, we found it quite difficult to extract relevant and meaningful information that can answer the research questions. This is because the primary studies included in this SR are mainly based on industry based experience reports and most of them are not described in a commonly used research paper structure. For this reason, two researchers performed data extraction independently. Extracted data from each researcher were compared and disagreements were discussed and resolved by consensus in meetings. For further disagreement, we consulted with a third independent researcher. We used a qualitative data analysis tool (NVivo) to store textual data that are able to address our research questions. We synthesized our data by identifying themes emanating from the findings reported in each of the paper reviewed in this study. In the following section, we present frequencies of the number of times each theme is identified in different studies. The respective frequencies reflect the number of times a particular challenge has been mentioned in different papers.

4 Results

4.1 Overview of Studies

Table 4.1 shows that the number of papers on the issue of using Scrum practices in GSD context are increasing over the last few years. It can be argued that the publication trend may be an indicator of practitioners and researchers' growing interest in using and reporting Scrum practices for GSD projects.

Table 4.1: Number of published papers by year interval

Year	2003	2004	2005	2006	2007	2008	2009
Papers	1	1	1	3	4	9	1
%	5%	5%	5%	15%	20%	45%	5%

Table 4.2: Type of studies reviewed in this review

Study Focus	Number of Papers	Percentage	Reference
Empirical Study	4	20%	[S1-4]
Industrial Experience Reports	16	80%	[S5-20]

Table 4.2 shows that only 4 studies (20%) included in this SR are empirical studies and all of them used industrial based in-depth case studies. Rest of the 16 studies (80%) is classified as industrial experience reports. These reports present the "lesson learned", "experiences" or any other "findings" from practicing Scrum in GSD projects. Hence, like Dyba and Dingsoyr [13], we also conclude that there is a little empirical evidence based reported on the use of Scrum practices in GSD context.

Table 4.3 presents various project contextual factors that have been identified from the reviewed studies. We have found that most of the studies report the use of Scrum practices in GSD projects from intra-organizational, multi-national companies. Our findings also reveal that a limited number of distributed sites are involved while Scrum practices are used in distributed sites. However, some researchers claim that a distributed project with multiple teams can also use Scrum in their development [1]. Scrum can also be used in a distributed project with very large team size. Some of the distributed projects can also use Scrum by minimizing the challenge of no overlap time between distributed sites. We have also found that a wide range of project domains ranging from simple web application to mission critical projects have been undertaken using Scrum in distributed development.

4.2 Findings about Research Questions

This section discusses how the data extracted from the reviewed studied address our research questions. By investigating the two research questions, we aim to

Table 4.3: Different project context factors identified from the reviewed studies.

Collaboration Mode	Intra organisational	16
	Inter organisational	4
Number of Sites	Two	15
	Three	5
	Three+	0
Number of Teams	Two	6
	Two+	12
	Unclear	2
Team Size	Up to twenty five	5
	Twenty five+	10
	Unclear	5
Time differences	No overlap time	10
	Overlap time	8
	Unclear	2
Application domain	Web	7
	Oil and energy	1
	Library	1
	Logistics	2
	Public safety	1
	Airline	1
	Commercial	2
	Business service	1
	Finance	1
	Unclear	3

provide a synthesized picture about and some insights into what the literature is reporting on using Scrum practices in different distributed projects.

RQ1- Challenges

We have identified sixteen papers that can help us to answer the research question 1 (RQ1), "What are the challenges of using Scrum practices in distributed development?" Our analysis of the extracted data reveal that the temporal, geographical and socio-cultural distance of GSD projects impact on using various Scrum practices in distributed settings. We have found that communication related issues are the major challenges when using Scrum in distributed settings. Cultural differences among distributed team members may also impact on team collaboration and communication. Managing a large team can also be considered as one of the key challenges. A lack of dedicated meeting room for each site, team distribution in multiple sites also appears to be challenging factors. Table 4.4 summarizes our findings of the key challenging of using the Scrum practices in GSD projects.

Usually sprint planning or retrospective sessions can last up to four hours or sometimes even more [10]. Thus, it is very difficult to conduct such a long meeting if the distributed teams are involved significant time zone differences. For this reason, lack of synchronous communication is considered the most vi-

Table 4.4: The key challenges of using Scrum practices in GSD projects.

Challenging factors	Paper references	Frequency (# of studies)
Synchronous communication	[S1-2,S6-7,S9-10,S16-17,S19]	9
Collaboration difficulties	[S1-3,S15-16,S19]	6
Communication Bandwidth	[S5-7,S15-16,S19-20]	6
Tool support	[S4, S10-11,S15-18]	6
Large Team	[S2,S5,S7,S10,S16]	5
Office Space	[S15-17]	2
Multiple sites	[S9]	1

tal challenge for using Scrum in GSD context. A distributed project usually involves people with cultural and linguistic diversity, which may discourage offshore team members from voicing their opinions or views fully and completely. This situation usually results in miscommunication, misunderstandings or confusion among team members. That means scrum teams may not be able to fully exploit the benefit promised by Scrum practices. For example, this SR has found that some Scrum teams could not conduct retrospective meetings because the teams were geographically distributed and involved socio-cultural distance [S1, S7]. Communication networks are often slow and unreliable, with poor transmission quality hampering communication standards when using various communication tools (e.g. video conferencing) [S15-16, S19]. Providing better communication bandwidth and right tool in a distributed project that use Scrum is vital [S17]. Lack of effective collaborative tools, global task boards, suitable bug and issue trackers, globally accessible backlog tool and so on is also considered a challenging factor [S10-11, S15]. Managing a project with a team of large number of members distributed at multiple sites has also been reported as a very challenging undertaking [S2, S5, S7]. The need of a dedicated meeting room with necessary infrastructure and tool support is also considered necessary in a number of reviewed studies [S15-17]. Using Scrum in a team that is distributed in more than two time zone differences is also considered quite difficult [S9].

RQ2- Used Strategies

This section discusses the existing Scrum team models that are commonly used by software development teams and described different strategies reported in the reviewed studies to tackle the challenges identified in previous section. **Scrum team model**: To cope with the challenges, three distributed Scrum team models are commonly observed in practice [10].

- Isolated Scrum: Project teams are geographically isolated and in most cases offshore teams are not cross-functional and may not use Scrum process.
- Distributed Scrum of Scrums: Scrum teams are isolated across geograph-

ical locations. The teams communicate via Scrum of Scrums, usually formed by representative persons form each scrum team.

- Fully Integrated Scrums: Scrum teams are cross-functional with team members are distributed across geographical locations.

Scrum product owner can use any team model or a combination of these models (for multiple teams) that can be suitable to his/her development environment. For example, Sutherland et al. report a case of using two Scrum team models for four development teams in which three of them were fully distributed and another was fully local [S3]. Hence, a GSD project with multiple teams can adopt hybrid team models depending on the nature of the project. We have categorized the 20 projects reported in the reviewed papers according to Scrum team models in Table 4.5.

Table 4.5: Distributed Scrum team model used in studies

Model	Isolated Scrum	Distributed Scrum of Scrums	Fully Integrated Scrum	Hybrid
Paper	0	5	13	2
%	-	25%	65%	10%
Reference	-	[S10-11,S18-20]	[S2, S4-9,S12-17]	[S1,S3]

Among the reviewed studies, we did not find any study reporting the use of isolated Scrum team model. Scrum Alliance's recommended best practice is a distributed Scrum of Scrums model that partitions work across cross-functional, isolated Scrum teams, which are linked by a Scrum of Scrums represented by Scrum masters [10]. We found only five experience reports that address this team model and there is no explicit case study. We also found a number of studies (65%) reporting the fully distributed Scrum team model. Two large projects using hybrid Scrum team model with multiple teams were also found.

Strategies to reduce challenges: Our SR found that Scrum product owners apply various practices to deal with the challenging factors that are commonly faced while using Scrum for globally distributed software development teams. We discuss them below:

Synchronous communication: Our SR found that Scrum teams used some strategies to provide synchronous communication when distributed team has no overlap time. From the reviewed papers, we found ten projects had distributed sites without any overlapping working hours. To address the lack of synchronous communication following practices were widely used.

- Synchronized work hours: This practice is widely used by Scrum teams to ensure synchronous communication among distributed sites can be arranged. This is done by adjusting working hours, working from home, working long hours and so on [S1-2, S6, S9, S13-14, S16-17, S19-20]. Some

Scrum teams used strategies to avoid the need of increased overlap time. For example, a Scrum team used strict time-boxed meeting (e.g. two hours planning meeting) to avoid late night meeting at some sites [S6]. To make the meetings short and effective, team members post their three daily Scrum questions or develop backlog (feature list) before attending the distributed meetings [S8, S10, S12, S15].

- Local Scrum: Due to the lack of overlap time, some Scrum teams choose the Scrum of Scrums team model and each site conducts their own scrum led by a local Scrum master [S6-9, S10-11, S18]. In order to connect one team with another, key touch points of each team (e.g. Scrum master) attends another meeting by using synchronized working hours practice frequently. For conducting a local Scrum, product owner should build autonomous local team and split the work based on functionality [S7-8]. In order to minimize the cross country dependencies, product owners usually allocate independent architectural subsystems with well defined interfaces to each sub team [S6, S9, S13]. To establish multiple communication lines, a product owner allows additional distributed meetings along with Scrum master meeting attended by technical lead or design architect of each local team [S9].
- Modified practices: Scrum masters can modify Scrum practices or use additional practices to address the communication challenges. For example, Berczuk reports that having a local "mini-scrum" in the morning after a distributed scrum meeting can be very effective to reinforce the value of the Scrum within a local team [S17]. Scrum masters also use strict communication policy (e.g. E-mail reply within 12 hours) to avoid delay due to the temporal distance of a distributed team [S9]. Instead of whole team presence in the late night (or early morning) Scrum meetings, only key members of the team attend the meetings with distributed teams [S5, S7, S13]. Moreover, the distributed daily Scrum meetings are usually cut down to twice-a-week meetings [S16]. We also found other modified practices such as asynchronous retrospective meetings (e.g., posting comments and results on Wikis, emailing the minutes of local Scrum meeting to the onshore team), conducting sprint demo by onshore team only (later onshore team briefs offshore team) [S1-3, S9, S13, S16].

Collaboration: To reduce the cultural differences and to increase team collaboration, the reviewed studies reported that Scrum teams used a number of practices that include:

- Team Gathering: To increase a project's domain knowledge and reduce the cultural distance, a Scrum team gathers and performs few initial sprints at one site before distributed development starts [S13, S15-19]. The members of a distributed Scrum team are also gathered quarterly or annually for few days [S1, S6, S10, S18]. During this gathering, a Scrum team can perform scrum planning, review meeting, retrospectives, sprint and various socializing activities, which can help to reduce cultural distance [S18].
- Visit: To reduce the cultural distance and increase project vision, a Scrum team adopts the practice of exchange visits throughout the development.

Product owners regularly visit offshore team [S15-16, S19]. Cultural exchange is also performed by maintaining planned rotation among offshore and onshore teams and cross-location visits [S14-15]. Practices like product owners organizing quarterly product roadmap meetings were also proven effective for helping team's members to fully understand a project's vision [S16].

- Unofficial distributed meetings: Along with formal meetings, distributed team members may also use informal distributed meetings for clarifying different issues. Such informal meetings can help reduce cultural misunderstanding [S1]. These unofficial meetings may involve leadership meetings, testing, and architectural meetings, distributed team lead meetings, peer meetings, and socializing meetings (for example, virtual party or games) or even "coffee talks" for the collocated team members [S14].

- Training: We also found that some Scrum teams also introduced a few additional practices such as organizing "technical Scrum" to clarify new technology issues, conducting an additional "unified planning meeting" attended by each Scrum master of multiple teams involved in a project. These practices helped overcome possible communication impediments and dependency among teams as well as to reduce cultural challenges [S9, S16].

- Key documentation: A Scrum product owner also keeps valuable documents that are expected to reduce misunderstanding and miscommunication caused by distributed project stakeholders [S7, S9, S16, S19]. For example, supplementing user stories with Use Cases and keeping a global backlog of user stories [S16].

- Mandatory participation: To reduce "offshore silence" challenge, a product owner can assign each site a thirty-minute mandatory demo presentation during retrospective sessions [S18]. The participation in these sessions helps make an empowered distributed team [S16]. To reduce cultural impediments, offshore teams are also encouraged to provide useful information during daily Scrum meetings [S1].

- Gradual team distribution: Scrum teams may move from a collocated project to a distributed project usually gradually through several stages (i.e., evaluation, inception, transition and steady state) [S13]. The gradual transition helps deal with the challenges caused by cultural distances and increases project domain knowledge. In one Scrum project, during initial three stages only a representative of an offshore team participated in Scrum meetings with onshore team. However, all members of the onshore and offshore teams participated in the distributed Scrum meetings [S13]. In another project, one onshore Scrum master facilitated offshore Scrum meetings for few initial sprints and came back to onshore when the local team became familiar with Scrum practices [S15].

Communication bandwidth and tools: Our SR has found that distributed Scrum teams tackle bandwidth challenges by using the practice multiple communication modes supported by several means and tools such as phone, web camera, teleconference, video conference, web conference, net meeting, email, shared

mailing list, IM, Short Message Service (SMS), Internet Relay chat (IRC), and so on [S1]. This practice provides a rich communication medium during the development. Scrum teams also use a number of collaborative and social networking tools such as Wikis, Blogs, social book marking, expertise finders, White boards, electronic work space, desktop and application sharing, photo charts, knowledge bases, experience data bases, lesson learned repositories [S1-20]. Scrum product owners use various tools for managing backlog, issue and bug tracking, and project management. The most commonly used tools reported the reviewed studies are "Jira" [S1-2, S4, S17], "Scrum works" [S3], Wikis [S20], "Rally" [S10] and different home grown tools [S7, S19].

Team management: We have found that Scrum product owners use different strategies to manage large teams. One commonly used strategy is to split a large team into small manageable teams (usually varies from three to fifteen persons) [S1-2, S5]. To build a sub-team, a Scrum master uses various strategies [S5, S13-14]. For example, the features that are highly volatile and need frequent interaction with the business users can be developed by forming a local sub-team [S3, S13]. Each sub-team is allocated a separate room [S1]. In some cases, each sub-team is assigned its own product owner (proxy) and Scrum master [S1, S3, S5]. The Scrum of Scrums is attended by the Scrum master or product owner of each sub-team in order to provide inter-team coordination [S1]. For multiple distributed sub-teams, frequently meetings among a centrally located product owner's team, a team of Scrum masters, and architects from sub-teams ensure effective coordination [S2].

Dedicated meeting room: For effective Scrum practice, each site should have one separate meeting room with necessary network connectivity and tools [S1, S3]. Each distributed site should have a video projector for making Scrum meetings visible for everyone [S15]. A virtual conference room can also support daily Scrum meetings or other meetings [S5].

Number of sites: To reduce the coordination and communication overhead, a Scrum team may be distributed at a limited number of sites. For example, one of the reviewed studies reports a project that was distributed among multiple sites but the Scrum team was distributed between two sites only [S9]. Hence, if a number of distributed sites are involved in a project, it is effective to split the work independently and use a Scrum of Scrums for team coordination [S14] or team distribution should be in limited sites [S9].

5 Discussion

In this section, we discuss the findings of our review to address our broad research question: what is currently known about the use of Scrum practices in GSD? We draw following conclusions from this review.

> **Conclusion 1.** There is a growing interest and literature demands more empirical study to understand the use of Scrum practices in GSD.

It is still an open debate whether or not the Scrum practices can successfully be used in distributed settings [8]. However, the increasing number of publications on this topic, as shown in table 1, appears to be an indication that there is an increasing interest in using Scrum practices in GSD projects. We have found that most of the papers and all the empirical studies have been published after 2007. Among the reviewed twenty studies, all of the four empirical studies and few experience reports have reported some degree of success in using Scrum practices in GSD. Despite these successes, the mechanics of combining Scrum practices and GSD are not well understood [2]. We also found that the number of primary studies on this topic is quite small; and only four of them can be considered empirical studies. These findings highlight a vital research gap that needs immediate attention of GSD and agile communities. Hence, there is a clear need of building empirically founded knowledge about using agile practices in general and Scrum practices in particular in the context of GSD.

> **Conclusion 2.** The use of Scrum practices in GSD may be limited by a project's contextual factors.

Our review has revealed that there can be several contextual factors of a project that may impact the use of Scrum practices in GSD. Some of the factors identified in the reviewed studies are shown in Table 2. Our findings also reveal that most of the distributed projects were within the same company; and the team distribution was limited by the number of distributed sites. We also found that there is a limited evidence of using Scrum for safety critical applications. Though our findings reveal that the Scrum practices can be used in a distributed project that has multiple numbers of teams, very large team size or even no overlap time between distributed sites, but the actual process is not clearly understood yet. We have not revealed the impact of other project contextual factors (for example: budget, complexity, criticality, team experience, time constraints, contract nature and so on) on using Scrum in GSD. Thus, we conclude that the use of Scrum practices may be limited by various contextual factors of a GSD project.

> **Conclusion 3.** Scrum teams usually face a number of challenges when they are globally distributed.

Our review findings reveal that the temporal, geographical and socio-cultural distances due to the project stakeholder's distribution cause a number of challenges related to communication, coordination and collaboration. The communication related challenges are identified as vital. Any cultural differences involved in a distributed team can substantially impact on the team's collaboration. Managing a large team distributed at multiple sites is quite challenging factor. A distributed Scrum team can also face a number of challenges because of lack of appropriate tools and insufficient infrastructure support.

> **Conclusion 4.** Scrum practices need to be extended or modified in order to support globally distributed software development teams.

Our findings reveal that to support the use of Scrum practices in various distributed projects, Scrum masters need to add a number of strategies suitable to their development environments. A distributed Scrum team can choose different Scrum team model to reduce its distribution challenges. A distributed

team usually needs some overlap time between them to carry out various Scrum meetings. To support a distributed team that has no overlap time, Scrum masters may use some supporting practices including synchronized work hours, local Scrum, additional local team meetings, strict communication policy, key persons attending all distributed meetings, reducing number of Scrum meetings, asynchronous retrospective and so on. To increase the collaboration in a Scrum meeting, Scrum team can also use some practices including team gathering, exchange visits, informal meetings of distributed team members, mandatory presentations, maintaining key documentation, and gradual team distribution which also help to reduce team cultural differences. A Scrum team can also use different practices such as multiple modes of communication to address the challenges caused by the lack of communication bandwidth and tools. A distributed Scrum team also needs to be supported by various tools for project management, backlog management, tracking issues and bugs and so on.

6 Limitations

Like any empirical study, this study also has certain limitations that should be kept in mind while considering the reported findings. With the increasing number of studies in this area, this review may have missed some papers that address the use of Scrum practices in GSD. However, we are certain that it would not have been a systematic omission. The papers included in this review have undergone a thorough selection process and involved two researchers cross checking the completeness of searchers and validating the suitability of each paper for inclusion. However, the findings of this review may have been affected by the systematic bias in describing the use of Scrum practices in various primary studies. Some of the reviewed studies describe the use of various Scrum practices along with other agile practices (e.g. XP practices). During the data extraction process, we found that several papers lacked sufficient details about the reported projects' contextual factors and the challenges faced and strategies used while using Scrum practices in GDS projects. We synthesized our data by identifying and categorizing the themes from the papers included in this review. Since some of the selected papers do not provide detailed information, there is a possibility that the extraction process may have resulted in some inaccuracies.

7 Conclusions and Future Research

We have conducted a systematic review of the literature on the use of Scrum of practices in GSD projects. The aim of this review was to identify the challenges involved in using the Scrum practices in GSD projects and the potential strategies to deal with those challenges. We have presented our findings in two stages; initial quantitative data presentation about the number of published papers in each year starting from 2003, the types of studies reported in the reviewed papers, the contextual factors of the reported projects. In the second stage, we have analyzed and interpreted the data extracted from the primary studies included in this review in order to find the answers to our research questions. The research questions are mainly related to the identification and synthesis of the reported challenges involved in using Scrum practices in GSD projects and

the strategies to deal with those challenges. Our analysis and interpretation of the data have enabled us to draw some general conclusions in Section 5 about the current state of practice of using Scrum practices in GSD projects. The results of this review provide information that can be useful for practitioners' understanding of different challenges involved in using Scrum practices in GSD projects. Moreover, the GSD project managers can also benefit from the synthesized knowledge about the strategies that are being used to deal with the identified challenges. However, the strength of evidence found in the literature about the identified strategies is very low. That is why it difficult to offer any specific advice to practitioners solely based on this review. This review has also identified several interesting research challenges that need to be addressed by the future research efforts of GSD and Agile researchers including ourselves. A clear finding of this review is that there is an immediate need of increasing the quantity and quality of empirical studies to describe, evaluate, explore and explain the use of various Scrum practices in GSD projects. To enhance the findings of this review, we intend to conduct a comprehensive survey of practitioners to identify the challenges involved in and the strategies for using various Scrum practices in GSD projects. In addition to this survey, we will also conduct an in depth case study to provide an empirically supported body of knowledge about the different challenges and strategies while using Scrum in a GSD project considering the project's contextual factors.

8 Appendix A. Papers included in the review

[S1] M. Paasivaara, S. Durasiewicz, C. Lassenius, "Distributed Agile Development: Using Scrum in a Large Project," Software Process Improvement and Practice, Vol. 13, Issue 6, pp. 527-544, 2008.

[S1a](Excluded) M. Paasivaara, S. Durasiewicz, C. Lassenius, "Distributed Agile Development: Using Scrum in a Large Project," in Proceedings of ICGSE 2008, pp. 87-95, 2008.

[S2] J. Sutherland,A.Viktorov, J. Blount, N. Puntikov, "Distributed Scrum: Agile Project management with Outsourced Development Teams" in Proceedings of the Conference on HICSS'40, pp. 274, 2007.

[S3] J.Sutherland, G. Schoonheim, M. Rijk, "Fully distributed Scrum: Replacing Local Productivity and Quality with Offshore Teams," in proceedings of the Conference on HICSS'42, pp. 1-8, 2009.

[S3a](Excluded) J. Sutherland, G. Schoonheim, E. Rustenburg, M. Rijk, "Fully distributed Scrum: The secret sauce for Hyperproductive Outsourced Development Teams" in Proceedings of the Conference on Agile 2008, pp. 339-344, 2008.

[S4] J. Cho, "Distributed Scrum for Large-Scale and Mission-Critical Projects," in Proceedings of the Conference on AMCIS 2007, paper 235, 2007.

[S5] W. Williams, M.Stout, "Colossal, Scattered, and Chaotic (Planning with a Large Distributed Team)," in Proceedings of the Conference on Agile 2008, pp. 356-361, 2008.

[S6] B. Drummond, J. F. Unson, "Yahoo! Distributed Agile: Notes from the World Over," in Proceedings of the Conference on Agile 2008, pp. 315-321, 2008.

[S7] M. Cristal, D. Wildt, R. Prikladnicki, "Usage of SCRUM Practices within a Global Company," in Proceedings of ICGSE 2008, pp. 22-226, 2008.
[S8] H. Holmstrom, B. Fitzgerald, P. J. Agerfalk, E. O. Conchuir, "Agile Practices Reduce Distance in Global Software Development" Information Systems Management, Summer, pp. 7-26, 2006.
[S9] M. Vax, S. Michaud, "Distributed Agile: Growing a Practice Together" in Proceedings of the Conference on Agile 2008.pp.310, 2008.
[S10] H. Smits, "Implementing Scrum in a Distributed Software Development Organization," in proceedings of the Conference on AGILE 2007, pp.371-375, 2007.
[S11] B. Jensen, A. Zilmer, "Cross- continent Development using Scrum and XP" in Proceedings of the Conference on XP 2003, pp.146-153, 2003.
[S12] C. Kussmaul, R. Jack, B. Sponsler, "Outsourcing and Off shoring with Agility: A Case Study" in Proceedings of the Conference on XP/Agile Universe, pp. 147-154, 2004.
[S13] K. Sureshchandra, J. Shrinivasavadhani, "Adopting Agile in Distributed Development" in Proceedings of ICGSE'08,pp. 217-221, 2008.
[S14] A. Danait, "Agile offshore techniques- A case Study" in proceedings of the Conference on Agile Development Conference, pp.214-217, 2005.
[S15] M. Summers, "Insights into an Agile Adventure with Offshore Partners," in Proceedings of the Conference on Agile 2008, pp. 333-338, 2008.
[S16] E. Therrien, "Overcoming the Challenges of Building a Distributed Agile Organization," in Proceedings of the Conference on Agile 2008, pp. 368-372, 2008.
[S17] S. Berczuk, "Back to Basics: The Role of agile Principles in Success with a Distributed Scrum Team," in Proceedings of AGILE 2007, pp. 382-388, 2007.
[S18] P. Karsten, F. Cannizzo, "The Creation of a distributed Agile Team," in proceedings of XP 2007, pp.235-239, 2007.
[S19] M. Cottmeyer, "The Good and Bad of Agile Offshore Development," in proceedings of the Conference on AGILE 2008, pp.362-367, 2008.
[S20] M. Paasivaara, C. Lassenius, "Could Global Software Development Benefit from Agile Method?" in proceedings of ICGSE 2006, pp. 109-113, 2006.

9 Appendix B. Data Extraction form

Paper description:

1. Paper identifier: Unique id for the paper
2. Date of data extraction:
3. Bibliographic reference: Author, year, title, source
4. Type of article: Journal article/conference paper/ workshop paper/unclear
5. Paper aims: what were the aims of this paper?
6. Paper Evidence: empirical study/experience report/unclear

GSD Background:

1. Collaboration mode: inter organizational/intra organizational/unclear
2. Number of Sites: .... /unclear
3. Number of Teams: ..... /unclear
4. Team size: ..... /unclear 5. Time zone differences: ..... /unclear 6. Application Domain: .... /unclear

Study Findings:

1. Distributed Scrum model: Isolated/Scrum of Scrum/Fully integrated/unclear
2. Challenges: challenges identified while using Scrum practices.
3. Strategies: Used various strategies to support Scrum practices in DSD projects.
4. Subjective evaluation: a small summary of the findings from the paper.

Bibliography

[1] J. Ronkainen . Abrahamsson, O. Salo and J. Warsta. *Agile software development methods - Review and analysis*. VTT Publications, Finland, vtt electronics ed. edition, 2002.

[2] P. J. Agerfalk and B. Fitzgerald. Flexible and distributed software processes: Old petunias in new bowls? *Communications of the ACM*, 49:26–34, October 2006.

[3] S. Ambler. Agile Adoption Rate Survey February 2008. $http://www.ambysoft.com/surveys/agileFebruary2008.html$.

[4] S. Ambler. Agile Practice and Principles Survey: July 2008. $http://www.ambysoft.com/surveys/practicesPrinciples2008.html$.

[5] K. Mohan B. Ramesh, L. Cao and P. Xu. Can distributed software development be agile? *Communications of the ACM*, 49:41–46, October 2006.

[6] E. Carmel. *Global software teams: collaborating across borders and time zones*. Prentice-Hall, New York, 1999.

[7] T. Dyba and T. Dingsoyr. Empirical studies of agile software development: A systematic review. *Information and Software Technology*, 50(9-10):833–859, 2008.

[8] D. Gendarmi F. Lanubile F. Abbattista, F. Calefato. ncorporating Social Software into Distributed Agile Development Environments. In *Proc. of he 23rd ASE workshop '08*, pages 46–51, 2008.

[9] J. D. Herbsleb. Global Software Engineering: The Future of Socio- technical Coordination. In *Proc. of the Future of Software Engineering, FOSE '07*, pages 188–298, 2007.

[10] K. Schwaber J. Sutherland. The Scrum Papers: Nuts, Bolts, and Origin of an Agile Process.
$http://scrumtraininginstitute.com/home/stream_download/scrumpapers$.